

REMARKS

Claims 1, 27, 53, 65 and 87 have been amended to better define the subject matter applicant regards as his invention, correct a typographical error and advance the application toward allowance. Claim 64 has been cancelled and new claims 88-130 added. Upon entry of this amendment claims 1-63 and 65-130 will be pending.

I. Rejection under 35 U.S.C. § 102(b)

Applicant requests reconsideration of the rejection of claims 1, 2, 22-25, 27, 28 and 51 under 35 U.S.C. § 102(b) as lacking novelty over U.S. Publication No. 2001/0018402, Ostgard et al. Applicant submits that the amended claims are novel over the cited reference.

Claim 1 is directed to a process for reforming an alcohol. The process comprises contacting a feed gas mixture comprising an alcohol with a reforming catalyst to produce a reforming product mixture comprising hydrogen. The reforming catalyst used in the process of claim 1 as amended comprises a metal sponge supporting structure and a copper coating at least partially covering the surface of the metal sponge supporting structure wherein the metal sponge supporting structure is prepared by a process comprising leaching aluminum from an alloy comprising aluminum and a base metal (e.g., nickel, cobalt, copper). A suitable copper coating can be deposited on the surface of the metal sponge supporting structure by various copper deposition processes, including electrochemical displacement deposition and electroless plating, to increase the overall copper content of the catalyst with the deposited copper predominantly present at or near the surface of the freshly

prepared catalyst (See, for example, page 19, line 26 to page 26, line 10 of applicant's specification).

Independent claim 27 is directed to a process for reforming ethanol. The process of claim 27 comprises contacting a feed gas mixture comprising ethanol with a reforming catalyst at a temperature below about 400°C to produce a reforming product mixture comprising hydrogen. The reforming catalyst comprises copper at the surface of a metal supporting structure.

It has been found in accordance with the claimed invention that catalysts comprising copper at the surface of a Raney metal sponge supporting structure exhibit the mechanical strength, high surface area, high thermal conductivity, and density of the sponge supporting structure combined with the desired catalytic activity of the copper such that it is particularly suited for gas-phase reforming of alcohols. In particular, the catalysts used in the practice of the present invention are stable in and particularly active for the thermal decomposition of ethanol into hydrogen, methane, carbon dioxide, and carbon monoxide at moderate temperature (i.e., below about 400°C).

Ostgard et al. disclose fixed bed Raney copper catalysts that can prepared as tablets, extrudates, hollow bodies, fiber tablets, granules bonded to a support or disc-shaped granules. The catalyst can optionally be doped with iron and/or noble metal and optionally other suitable doping metals in an amount of 10 ppm to 1% by weight. The disclosed catalysts are said to be useful in the liquid-phase dehydrogenation of alcohols (e.g., benzyl alcohol, ethanol, and amino alcohols such as diethanolamine to the corresponding aminocarboxylic acid salt).

By contrast, the alcohol reforming processes of independent claims 1 and 27 require contacting a feed **gas** mixture comprising the alcohol to be reformed with the reforming catalyst. Nowhere

do Ostgard et al. teach or suggest that the catalyst they disclose is suitable for **gas-phase** dehydrogenation of an alcohol as called for in independent claims 1 and 27. Rather, the dehydrogenation reactions envisioned by Ostgard et al. are all conducted in the **liquid-phase**. According to Ostgard et al., it is necessary that the dehydrogenation process be conducted under pressure sufficient to maintain the alcohol in the liquid-phase because the alcohols have a high vapor pressure and if the pressure is reduced to let off hydrogen, the alcohol would also be vaporized under too low of a pressure (See paragraphs [0032] and [0033]). Furthermore, Ostgard et al. teach that in the case of dehydrogenating alcohols which react with a strong base to give the carboxylate, it is necessary that the alcohol and the resulting carboxylate are stable in strongly basic solution and that the alcohol is at least somewhat soluble in water (See paragraph [0018]). In the only example in Ostgard et al. of a dehydrogenation reaction carried out utilizing the disclosed catalyst [Example 10 - conversion of diethanolamine (DEA) to sodium salt of iminodiacetic acid (IDA)], the reaction was "carried out in a fixed tubular reactor with a liquid circulation" under a pressure of 10 bar (See paragraphs [0060] and [0065]).

Moreover, Ostgard et al. fail to disclose use of a catalyst which comprises a copper coating at least partially covering the surface of a metal sponge supporting structure as required in the alcohol reforming process of claim 1, and fail to teach or suggest the use of the disclosed catalyst in the gas-phase reforming of ethanol at temperatures below about 400°C as required by the ethanol reforming process defined in independent claim 27.

Accordingly, independent claims 1 and 27 and claims 2, 22-25, 28 and 51 depending therefrom are novel over the disclosure in Ostgard et al.

II. Rejections under 35 U.S.C. § 103(a)

Claims 3 and 32

Applicant respectfully requests reconsideration of the rejection of dependent claims 3 and 32 under 35 U.S.C. § 103(a) as obvious over Ostgard et al. in view of U.S. Patent No. 6,077,620 issued to Pettit.

Claim 3 depends indirectly from independent claim 1 and claim 32 depends from independent claim 27. Claim 3 and claim 32 further require introducing hydrogen from the reforming product mixture and oxygen into a fuel cell to produce electric power.

Pettit is directed to a fuel system in which a hydrogen-containing liquid fuel (e.g. alcohol or hydrocarbon) is fed to a fuel reformer for production of hydrogen for use in a fuel cell. A catalyzed combustor can be fueled by either the liquid fuel or residual hydrogen from the anode of the fuel cell. The hot combustor exhaust gas can be fed to a heat exchanger to transfer heat to the catalyst bed of the reformer. The fuel mixture is vaporized before being fed to the reformer (Col. 3, lines 28-36). Pettit is silent as to the nature of the catalyst used in the reformer.

In order to establish a *prima facie* case of obviousness, the prior art reference(s) must teach or suggest all the claim limitations, there must be some suggestion or motivation, either in the reference(s) itself or in the knowledge generally available to one of ordinary skill in the art, to modify the

reference or combine reference teachings and obtain the claimed invention, and there must be a reasonable expectation of success. MPEP § 2142. Applicant respectfully submits that the Office has failed to establish a *prima facie* case of obviousness with respect to the invention defined in claims 3 and 32.

Neither Ostgard et al. nor Pettit disclose use of a reforming catalyst comprising a copper coating at least partially covering the surface of a metal sponge supporting structure as required by independent claim 1 and fail to teach or suggest a process for the gas-phase reforming of ethanol wherein the reforming reaction is conducted at a temperature below about 400°C as required by independent claim 27.

Furthermore, the Office's contention that it would be desirable to use the reforming process of Ostgard et al. in the fuel cell system of Pettit in order to provide hydrogen from ethanol as fuel for the fuel cell misconstrues the disclosure in Ostgard et al. As noted above, Ostgard et al. only contemplate use of the disclosed fixed bed Raney copper catalysts in the liquid-phase dehydrogenation of alcohols and nothing in the disclosure of Ostgard et al. teaches or suggests that the catalysts disclosed therein could be employed in the gas-phase reforming of an alcohol. One skilled in the art would not have been motivated to incorporate the reforming process of Ostgard et al. into the fuel cell system of Pettit with a reasonable expectation of success since Pettit's reformer catalytically dehydrogenates hydrogen-containing fuels in the gas-phase and nothing in the disclosure of Pettit regarding the catalyst used in the reformer would suggest or motivate one skilled in the art to incorporate the liquid-phase dehydrogenation catalyst and process of Ostgard et al.

In view of the above, applicant respectfully submits that the Office has failed to establish a *prima facie* case of obviousness with respect to the invention defined in claims 3 and 32 based on the disclosure in Ostgard et al. and Pettit.

Claims 4-26, 29-31 and 33-52

Applicant respectfully requests reconsideration of the rejection of dependent claims 4-26, 29-31 and 33-52 as obvious over Ostgard et al. in view of "Raney Nickel-Copper Catalysts II: Surface and Pore Structures" authored by Wainwright et al.

Wainwright et al. characterize activated nickel-copper-aluminum alloys (i.e., copper-doped Raney nickel or nickel-doped Raney copper) through various physical adsorption, chemisorption and temperature-programmed desorption (TPD) experiments.

The catalysts characterized by Wainwright et al. are activated nickel-copper-aluminum alloys and do not contain a copper coating. Thus, both Ostgard et al. and Wainwright et al. fail to disclose the catalyst utilized in the alcohol reforming process of claim 1 and, indirectly, depending claims 4-26. Further, Wainwright et al. and Ostgard et al. do not disclose any process for gas-phase reforming of ethanol, let alone such a process wherein the ethanol reforming reaction is conducted at a temperature below about 400°C as called for in claim 27 and, indirectly, depending claims 29-31 and 33-52.

On page 5 of the Office action, the Office contends that "[i]t would be advantageous to use any of the variations of the catalysts [of] Wainwright et al. including nickel as the catalyst of Ostgard et al. since hydrogen evolution increases with increasing amounts of nickel in a Raney copper catalyst. Therefore, it would have been obvious to one having ordinary skill in the art at the time the invention was made to use the

catalyst of Wainwright et al. in order to improve hydrogen generation in Ostgard et al."

The Office has misunderstood the disclosure in Wainwright et al. The hydrogen "evolved" from the catalyst of Wainwright et al. referred to in the abstract of the reference was not produced catalytically in a dehydrogenation reaction, much less the gas-phase reforming of an alcohol, but rather is hydrogen left adsorbed on the catalyst after the catalyst is formed by activating the copper-nickel-aluminum alloy and later desorbed during TPD studies (See pp. 125-126; pp. 128-129; Table 3; and Figs. 3 and 4). Similarly, the hydrogen referred to in Table 2 of Wainwright et al. was used as a probe during chemisorption studies of the catalysts and the quantity of chemisorbed hydrogen was shown to decrease rapidly as the copper content of the catalysts increased (See pp. 127-128).

Wainwright et al. acknowledge that they did not evaluate the catalytic properties of the Raney copper-nickel catalysts (See p. 130, Col. 1, lines 10-11). In discussing catalytic activity studies performed by others previously, Wainwright et al. fail to mention any study assessing the activity of the Raney catalysts in dehydrogenation reactions generally and especially in gas-phase reforming of alcohols (See p. 130).

Accordingly, in view of the above, applicant respectfully submits that the deficiencies in Ostgard et al. with respect to independent claims 1 and 27 cannot be overcome by resort to Wainwright et al. such that the Office has failed to establish a *prima facie* case of obviousness with respect to the invention defined in dependent claims 4-26, 29-31 and 33-52.

Claims 53-57

Applicant respectfully requests reconsideration of the rejection of claims 53-57 as obvious over Pettit in view of Ostgard et al.

Independent claim 53 is directed to a process for producing electric power from a fuel cell. As amended, the process includes contacting a feed gas mixture comprising ethanol with a dehydrogenation catalyst at a temperature below about 400°C in a dehydrogenation reaction zone to produce a product mixture comprising hydrogen. The dehydrogenation catalyst comprises copper at the surface of a metal supporting structure. The hydrogen from the product mixture and oxygen are introduced into a fuel cell to produce electric power and a fuel cell effluent comprising methane. The fuel cell effluent and oxygen are introduced into a combustion chamber and the fuel cell effluent is combusted in the combustion chamber.

Neither Pettit nor Ostgard et al. disclose a process for producing electric power from a fuel cell wherein a feed gas mixture comprising ethanol is contacted with a dehydrogenation catalyst at a temperature below about 400°C. Further, neither Pettit nor Ostgard et al. disclose a fuel cell power system wherein hydrogen and oxygen are introduced into a fuel cell to produce electric power and a fuel cell effluent comprising methane. While Pettit teaches that the fuel cell effluent of his power system contains hydrogen (Col. 5, lines 26-30) he fails to teach or suggest a fuel cell effluent comprising methane or a fuel system wherein the fuel cell effluent would necessarily contain methane.

Moreover, as noted above, Ostgard et al. only disclose use of the catalyst they disclose in the liquid-phase dehydrogenation of alcohols. Thus, contrary to the assertion on

page 6 of the Office action, nothing in the disclosure of the cited references would teach or suggest an advantage in substituting the catalyst taught by Ostgard et al. into the fuel reformer of Pettit with a reasonable expectation of success since Pettit's reformer catalytically dehydrogenates hydrogen-containing fuels in the gas-phase and nothing in the disclosure of Pettit regarding the catalyst used in the reformer would suggest or motivate one skilled in the art to incorporate the liquid-phase dehydrogenation catalyst and process of Ostgard et al. Accordingly, and for the reasons set forth above, independent claim 53 and claims depending therefrom including claims 54-57 are submitted as patentable over Pettit in view of Ostgard et al.

Claims 4-26, 29-31, 33-52 and 64-87

Applicant respectfully requests reconsideration of the rejection of dependent claims 4-26, 29-31 and 33-52 in paragraph 7 of the Office action as obvious over Ostgard et al. in further view of Wainwright et al. Applicant notes that although claim 87 is not mentioned in paragraph 7 of the Office action, it is recited in the paragraph bridging pages 4 and 5 of the Office action, and it is applicant's understanding that original claim 87 was intended to be included in the rejection as it depended from rejected claim 39.

Applicant also respectfully requests reconsideration of the rejection of dependent claims 4-26, 29-31, 33-52 and 64-87 in paragraph 9 of the Office action as obvious over Pettit in view of Ostgard et al. as applied to independent claim 53, in further view of Wainwright et al. While applicant notes that that the Office action states that claims 4-26, 19-31, 33-52 and 64-87 are rejected in paragraph 9 of the Office action, applicant

believes the Office intended to reject only original claims 64-86 which depend directly or indirectly from claim 53.

Regardless of this confusion, applicant respectfully submits that claims 4-31, 33-52 and 87 are patentable for the reasons stated above in response to the rejection of claims 4-26, 29-31 and 33-52 as obvious over Ostgard et al. in further view of Wainwright et al. None of the references, including Pettit, teach use of a catalyst comprising a copper coating at least partially covering the surface of a metal sponge supporting structure as required in claim 1 or a process wherein the ethanol reforming reaction is conducted at a temperature below about 400°C as required by independent claim 27 or teach use of the catalyst defined in independent claims 1 and 27 in the gas-phase reforming of an alcohol. As such independent claims 1 and 27 and all claims depending therefrom are nonobvious over the cited references.

Regarding claims 64-86, on page 8 of the Office action, the Office again contends that it would be advantageous to use any of the variations of the catalysts of Wainwright et al. in the reformer of Pettit since hydrogen evolution increases with increasing amounts of nickel in a Raney copper catalyst. As noted above, the Office has misinterpreted the disclosure in Wainwright et al. with respect to hydrogen evolution and the reference fails to teach or suggest use of the catalyst disclosed therein in the catalytic reforming of an alcohol. Accordingly, Wainwright et al. do not provide the purported motivation to combine the teachings of the cited references. Further, neither Pettit, Ostgard et al. nor Wainwright et al. teach or suggest a process for producing electric power from a fuel cell wherein a feed gas mixture comprising ethanol is contacted with a dehydrogenation catalyst at a temperature below

about 400°C or a process wherein a fuel cell effluent comprising methane is produced as required by independent claim 53.

Accordingly claim 53 and all claims depending therefrom are patentable over Pettit in view of Ostgard et al. in further view of Wainwright et al.

Claims 58-60

Applicant respectfully requests reconsideration of the rejection of dependent claims 58-60 as obvious over Pettit in view of Ostgard et al. and further in view of U.S. Patent No. 4,820,594 issued to Sugita et al.

Sugita et al. is directed to a fuel system wherein a fuel is fed to a fuel reforming part 113 of a reformer 101. The reforming product mixture is passed through a fuel cell 102. The effluent from the fuel cell anode is cooled in a heat exchanger 105 and moisture is removed from the effluent in knockout drum 106. The outlet gas is heated in heat exchanger 105 and sent to a combustion part 112 of the reformer 101 where it is combusted to transfer heat to the reforming part 113 of the reformer. The combusted gas is sent to the cathode side 105 of the fuel cell 102. The cathode effluent can be recycled and/or sent to a combustor 117 and then fed to a turbine 118. The turbine 118 drives an air compressor 116 and a generator 119. Sugita is silent as to the nature of the catalyst used in the reformer.

Pettit, Ostgard et al. and Sugita et al. fail to disclose a process for producing electric power from a fuel cell wherein a feed gas mixture comprising ethanol is contacted with a dehydrogenation catalyst at a temperature below about 400°C. Further the references fail to teach or suggest a fuel system wherein the fuel gas mixture comprises ethanol and a fuel cell

effluent comprising methane is produced. Applicant acknowledges that the fuel cell effluent of Sugita et al. may contain methanol. For instance Sugita et al. teach that methane can be a suitable feed gas and that the gas stream after reforming contains hydrogen, carbon monoxide, water, carbon dioxide and methane (Col. 4, lines 12-15). Not all of the reformed fuel needs to be consumed in the cell but rather can be used as fuel for the combustion heating part 112 of the reformer 101 (Col. 4, lines 52-57). However, nowhere do Sugita et al. teach or suggest a process wherein the fuel cell effluent comprises methane when the fuel gas fed to the process comprises ethanol (Col. 3, lines 46-50) as required by independent claim 53.

Moreover, as stated above, Ostgard et al. only disclose use of the catalyst they describe in the liquid-phase dehydrogenation of alcohols. It would not be advantageous to use the catalyst taught by Ostgard et al. in the reformer of Pettit as Pettit's reformer catalytically dehydrogenates hydrogen-containing fuels in the gas-phase. None of the cited references teach or suggest use of a liquid-phase dehydrogenation catalyst as taught by Ostgard et al. in a reformer to catalytically reform an alcohol-containing feed gas mixture. Accordingly independent claim 53 and claims depending therefrom including claims 59 and 60 are submitted as nonobvious over Pettit in view of Ostgard et al. in further view of Sugita et al.

Claims 61-63

Applicant respectfully requests reconsideration of the rejection of dependent claims 61-63 as obvious over Pettit in view of Ostgard et al. in further view of U.S. Patent No. 6,541,142 issued to Yu et al.

Yu et al. disclose a fuel cell system wherein an organic fuel, preferably methanol, is vaporized in a vaporizer 28 and is fed to a steam reformer 36. The reformed product mixture is sent to a carbon monoxide adsorber 38 and a preferential oxidation reactor 18. The effluent is sent to a fuel cell stack 42. Excess hydrogen not used in the fuel cell stack 20 may be sent to the catalytic combustor 16. The combustion products may heat the contents of the vaporizer 28 and are then charged to the atmosphere 30. During cold startup a fuel such as methanol is sent to the catalytic combustor 16 and the resulting effluent is sent through the system via line 34 until excess hydrogen exits the fuel stack for use in the catalytic combustor. Methanol fuel is sent to the methanol decomposition reactor 14 once it reaches its temperature setpoint. The effluent from the methanol decomposition reactor is fed to the steam reformer 36 until the steam reformer reaches its operating temperature setpoint. A copper-zinc catalyst is said to be suitable for methanol steam reforming (See Col. 2, lines 21-25).

Yu et al. fail to disclose a process for producing electric power from a fuel cell wherein a feed gas mixture comprising ethanol is contacted with a dehydrogenation catalyst at a temperature below about 400°C. Further, while Yu et al. teach that excess hydrogen may be found in the fuel cell effluent (Col. 6, lines 11-12) they fail to disclose the presence of methane in the fuel cell effluent, and particularly the presence of methane in the fuel cell effluent when the fuel gas mixture sent to the reformer comprises ethanol. Further Ostgard et al. only disclose use of the catalyst they describe in the liquid-phase dehydrogenation of alcohols and none of the cited references teach or suggest use of a liquid-phase dehydrogenation catalyst as disclosed by Ostgard et al. in a

reformer to catalytically reform an alcohol in the gas-phase. Accordingly independent claim 53 and claims depending therefrom including claims 61-63 are nonobvious over Pettit in view of Ostgard et al. in further view of Yu et al.

Claim 117

Independent claim 117 and dependent claims 118-130 have been added and are directed to a process for reforming an alcohol. The process of claim 117 comprises contacting a feed gas mixture comprising an alcohol with a reforming catalyst to produce a reforming product mixture comprising hydrogen wherein the reforming catalyst is prepared by a process comprising depositing copper on a metal sponge supporting structure. Applicant submits that the claim is patentable as none of the cited references disclose a catalyst prepared by a process comprising depositing copper on a metal sponge supporting structure, let alone use of such a catalyst in the gas-phase dehydrogenation of an alcohol.

Favorable reconsideration and allowance of all pending claims are respectfully requested.

The Commissioner is requested to charge the excess claim fee and any fee deficiency or overpayment in connection with this amendment to Deposit Account 19-1345.

Respectfully submitted,



Michael J. Vander Molen, Reg. No. 57,274
SENNIGER POWERS
One Metropolitan Square, 16th Floor
St. Louis, Missouri 63102
(314) 231-5400